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REPORT ON PRELIMINARY INVESTIGATION

FOR

MIDTOWN HUDSON TUNNEL

BETWEEN

MANHATTAN, NEW YORK CITY

AND

WEEHAWKEN, NEW JERSEY

JANUARY 9, 1931

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JANUARY 9, 1931

ALBANY
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80–90 EIGHTH AVENUE, NEW YORK CITY

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CONSULTING GEOLOGIST

PROF. CHAS. P. BERKEY

New York, January 9, 1931.

To the Governor and Legislature of the State of New York:

To the Governor and Legislature of the State of New Jersey:

SIRS,— Chapter 420 of the Laws of New York, 1930, and Chapter 248 of the Laws of New Jersey, 1930, directed the Port Authority to proceed with studies and plans for the so-called Midtown Hudson Tunnel and report results to the 1931 sessions of the Legislatures. The report of our Chief Engineer, based upon engineering and other studies, is transmitted herewith.

This body has often reported the need for additional interstate transportation facilities. We have felt for years the importance to the public welfare and to the Port's industry in particular, of a series of crossings adequate to meet the expanding and growing needs of the District. We recognize that in their capacities as shippers, travelers, taxpayers, workers and voters, the public finally determines the facilities which shall be provided. In response to their needs, the necessary directions to go forward with the needed public transportation facilities must come from the legislatures of the two States. The report of the engineers gives us all of the data that could be obtained regarding geologic formations, subaqueous conditions, methods of construction, workable solutions of the approach problems, etc., but transcending all of these things is the principle of easy and available intercommunication between various parts of the Port. At first glance the estimated cost of $96,000,000 might arouse some doubts as to its feasibility, but careful traffic estimates showing travel amounting to 12,500,000 vehicles during the first year of operations should dispel any hesitancy. At an average toll of 55 cents, this will yield $6,875,000 annually,— more than enough to pay operating costs, interest charges and amortization.

Such a facility is needed. We recommend that authority be granted at once to the Port Authority to proceed. Immediate financing can be arranged and the tunnel can be completed for operation by 1937.

Of course, the engineers' report does not show that all of the problems connected with a facility of this magnitude have been solved. That will take many months. But with the advice and help of public officials and engineering authorities, determination of the most important principles has been reached. For the subaqueous portion of the tunnel, the shield-driven method of construction is recommended; the New York portal should be in the vicinity of 38th street

west of Ninth avenue; unnecessary interference with the New York Central's West Side Development should be avoided — the approach problem on the New Jersey side is a difficult one, but either the "open cut" method or the tunnel method offers a solution from an engineering point of view. Indeed, as in all construction of this nature, a start is made with only general plans in mind, and as the work progresses, revisions are made as experience and actual working conditions may dictate.

By your direction we have taken the necessary preliminary steps toward this great work. We now await your specific instructions to proceed with its accomplishment.

So much for this one facility.

But we should like to take this opportunity to set forth certain principles which have been evolved from months of study of the transportation problem. The progress and prosperity of the Port District, particularly in view of the complexity of its economic character, depend to a very large extent upon its transportation facilities. Without easy intercommunication, no section of the Port will reach its proper stage of development. Easy means of communication and transportation between all sections of the Port must be provided if we are to maintain our position in the Nation's progress. For the past ten years or so, it has become increasingly apparent that the transportation facilities in the Port District have not expanded sufficiently to meet the increased demand for transportation.

Recognizing these facts during the last sessions of the Legislatures of New York and New Jersey, serious consideration was given this problem. The pressing need for a second vehicular tunnel precipitated the discussion, inasmuch as the rapidly mounting volume of Holland Tunnel traffic clearly indicated that another tunnel would soon be needed. The press, civic and trade associations, sensing that the problem was a vital one, considered the subject seriously, and eventually a joint conference of the Governors and legislative leaders was called. Their deliberations led to the enactment of legislation which in effect merged the New York and New Jersey Tunnel Commissions with the Port Authority and placed under the control of the reconstituted body all existing interstate vehicular crossings as well as those under construction, with directions to proceed with studies and plans for the construction of a second vehicular tunnel as reported on above.

Our deliberations have naturally led us to an outlook broader than that of providing one additional facility. The policy indicated by the legislation enacted by the two States last Spring has apparently placed upon this body the duty of recommending not merely specific plans for one additional crossing with an unrelated plan of financing its construction, but rather to consider the broader obligation of submitting a complete program dealing with the entire problem of interstate vehicular traffic in the Port District. We submit these principles in the hope that there will follow legislation which will establish a sound public policy

pursuant to which the Port Authority may proceed not only to construct the next vehicular crossing but also to have directions in a general program of construction which will provide, as the necessity arises, all adequate accommodation.

We again call to your attention the transportation needs which exist here in this District — the gateway to the Nation. Traffic is increasing at a rapid rate; it passes and repasses between the counties of Bergen, Hudson, Union and Middlesex in New Jersey, and the counties of New York, Bronx, Kings and Richmond in New York. The four bridges which, pursuant to your authority, we are now constructing or have in operation between certain sections, will provide adequate accommodation for much of this area for some time to come; but the area lying between the Battery in New York and Greenville in Jersey City, and the southerly limits of the traffic zone to be served by the Hudson River Bridge has now only one fixed crossing — the Holland Tunnel. Within this area which probably has the most intense traffic movement in the world and in which the growth of traffic is most rapid, the lack of interstate traffic facilities is the greatest. We can conservatively count upon an average daily traffic of 280,000 vehicles between Manhattan and New Jersey within twenty-five years. Today there is an average daily traffic of 65,000 vehicles between these two sections served by the one vehicular tunnel and by the ferries. The absolute capacity of the Holland Tunnel is 60,000 vehicles per day.

Vision, courage, competency, careful studies and serious application are necessary to its solution. Each new facility must be located at the most advantageous point. They all must be under unified control and operation. Unsound and expensive financing, hit-or-miss location, unrelated operation and lack of foresight must be avoided.

That the States may now establish a sound, constructive policy which will anticipate the needs of vehicular traffic within the Port District and carry forward the construction of facilities to meet such needs, we recommend the following for your consideration as a proposed basis for an interstate policy:

1. A program which will include immediate authorization of the Midtown Hudson Tunnel, and constant study of the situation so that further construction may be anticipated and recommendations made to the Legislatures for authorization to construct additional facilities as traffic demands may require.

2. Place under the Port Authority the control and operation of all fixed vehicular crossings. This will make possible economies in operation and standardization in practices and regulations for the greater convenience of the public. It will also make possible the establishment of special rates for the use of more than one facility on one trip, and the consequent economy in the movement of traffic. It will avoid competitive rates with their menace to the financing of future construction.

3. Pool surplus revenues. This is the logical financial formula if the policy of unification is accepted. The excess revenues from all facilities should flow into a common reservoir or pool, thus insuring to the holders of each separate bond issue greater security. This will materially improve the credit rating of the Port Authority and will reduce the cost of future construction.

It is recommended that the necessary legislation be enacted to carry out the foregoing policy. As a logical and necessary step in effectuating a program of unification, it is recommended that you authorize the placing of control of the Holland Tunnel under the Port Authority on the same basis as the four interstate bridges. Such a result can be accomplished by the Port Authority issuing bonds and refunding to the two States the unliquidated balance of its cost with interest at $4\frac{1}{4}$ per cent. In other words, each State will have returned to it approximately $25,800,000. New York, having made its share of cost available by direct appropriation, will have this sum returned to its treasury. New Jersey, having made its share of cost available by a bond issue, will have this sum deposited in its sinking funds for the amortization of its bonded indebtedness in behalf of Holland Tunnel construction.

There are many details of this problem regarding which it is not felt that specific recommendations should be made at this time, involving as they do questions of public policy to be determined by the Governors and Legislatures of the two States. With respect to these, we hold ourselves in readiness to furnish you with whatever assistance and information may be requested of us.

Respectfully submitted,

The Port of New York Authority

JOHN F. GALVIN,
Chairman,
FRANK C. FERGUSON,
Vice-Chairman
HOWARD S. CULLMAN,
JOHN F. MURRAY,
GEORGE R. DYER,
JOHN J. PULLEYN,
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IRA R. CROUSE,
Commissioners.

THE PORT OF NEW YORK AUTHORITY

January 3, 1931

REPORT OF THE CHIEF ENGINEER ON THE PRELIMINARY INVESTIGATION FOR THE MIDTOWN HUDSON TUNNEL

To: Mr. J. E. Ramsey, *General Manager:*

By concurrent Acts of the Legislatures of New York and New Jersey which became effective April 21, 1930, The Port of New York Authority was authorized and directed to report to the Legislatures of the two States upon a tunnel or tunnels for vehicular traffic under the Hudson River between a point or points in the vicinity of Thirty-eighth street, west of Ninth avenue in the Borough of Manhattan, City of New York, and a point or points west of the Palisades in the State of New Jersey, such tunnel or tunnels to have entrances and exits on the east side of said Palisades, in the township of Weehawken, county of Hudson.

In compliance with the above authorization and direction, The Port of New York Authority has undertaken extensive traffic studies to determine the utility of a river crossing at the site stipulated and the anticipated revenue therefrom, field work, including topographic surveys, triangulation and borings, design studies to determine the best type of tunnel structure, studies to determine the arrangement of the approaches and estimates of cost of construction and appraisal of real estate. These studies have been carried to a stage which permits the drawing of the following conclusions:

CONCLUSIONS

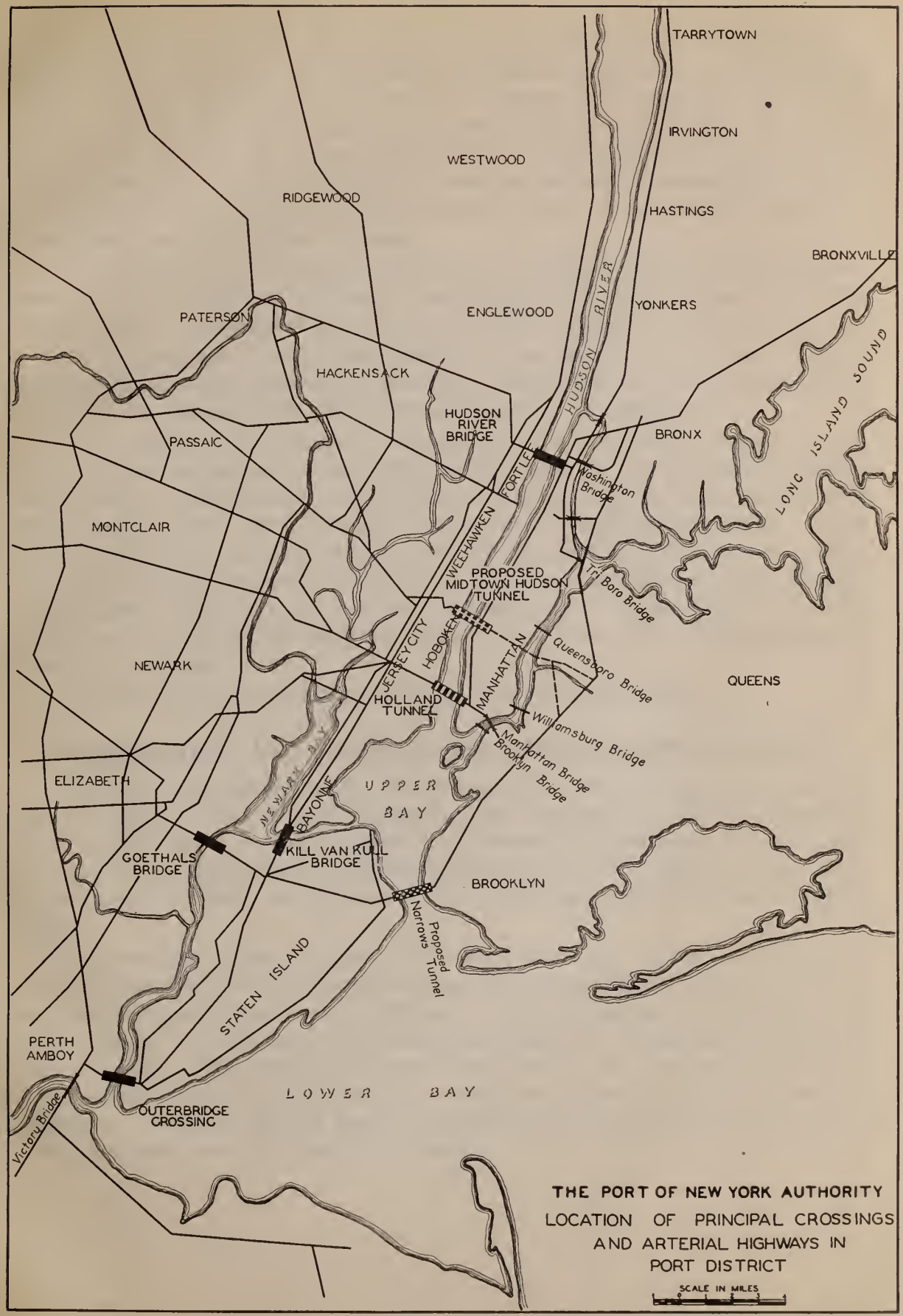
1. Traffic studies indicate a demand for a vehicular crossing opposite the Midtown Manhattan area. The Holland Tunnel located approximately two and one-half miles south of the proposed location is now carrying an annual traffic of twelve million vehicles or nearly seventy per cent of its estimated annual capacity. On holidays and times of peak load the demand already exceeds the capacity. It is estimated that the annual capacity of the Holland Tunnel will de fully reached before the proposed tunnel is ready for operation. The Hudson River Bridge, located seven miles north of the proposed tunnel site, will serve largely the demands of traffic between upper Manhattan, Westchester and New England and com-

munities opposite in New Jersey and considerably north of the proposed site for the vehicular tunnel.

2. As a result of numerous studies for the New York approach which were made in collaboration with representatives of the city government, and in which consideration was given to connections with other traffic facilities, the effect on public and private property, cost of real estate and construction costs, a location of the terminus of the tunnel in New York City in the vicinity of 38th street, west of Ninth avenue, is recommended. Traffic investigations indicate that the capacity of the streets in that vicinity will be more than sufficient to take care of the tunnel traffic in addition to the street traffic. The proposed location of the Manhattan terminus will permit easy access to the West Side Express Highway. It will also be convenient with respect to the East River Vehicular Tunnel to be constructed by the city at 38th street. In case the city should decide to build a crosstown tunnel in line with the Thirty-eighth street East River Tunnel, it will be feasible to connect that tunnel with the Manhattan terminus of the Hudson Tunnel and thus permit the portion of the trans-Hudson traffic which will desire to reach points on the east side of Manhattan and in Long Island to use the Crosstown Tunnel without traversing the city streets.

3. For the New Jersey approach a five-lane open cut highway with connections with local highways at Weehawken east of the Palisades, connection with the Hudson County Boulevard on top of the Palisades and a terminus in the vicinity of the intersection of State Highway Routes Nos. 1 and 3 at Homestead, west of the Palisades, offers a workable solution. The proposed location of this New Jersey approach, besides accommodating long distance traffic, is ideally suited to serve local interests. Hoboken, Weehawken, North Bergen and other communities located along the Palisades will be provided with direct access to New York by means of a connection at Weehawken. It is estimated that these communities will furnish 45 per cent of the trans-Hudson traffic through this tunnel. This approach highway by its connection with the Hudson County Boulevard will not only facilitate travel between the tunnel and the thickly populated localities at the top of the Palisades, but will also offer improved communication between these important communities and points in New Jersey east and west of the Palisades. The Homestead connection will provide access to State Highway Routes Nos. 1 and 3 and to a new State Highway route which it is proposed to construct across the Meadows over the Hackensack and Passaic rivers to serve the interests of the communities to the south and southwest.

4. The main tunnel under the Hudson River is to consist of twin tubes to be built by the shield driven method. This construction procedure will follow very closely that so successfully used for the Holland and other tunnels. Each of the two tubes is to have an outside diameter of 31 feet and is to accommodate a two lane roadway of a width of at least 21 feet, which is one foot more than in the


TARRYTOWN
IRVINGTON
WESTWOOD
RIDGEWOOD
HASTINGS
BRONXVILLE
PATERSON
ENGLEWOOD
YONKERS
HUDSON RIVER
HACKENSACK
HUDSON RIVER BRIDGE
PASSAIC
BRONX
LONG ISLAND SOUND
Washington Bridge
FORTLEE
MONTCLAIR
WEEHAWKEN
PROPOSED MIDTOWN HUDSON TUNNEL
Triboro Bridge
HOBOKEN
JERSEY CITY
MANHATTAN
Queensboro Bridge
NEWARK
QUEENS
HOLLAND TUNNEL
Williamsburg Bridge
Manhattan Bridge
Brooklyn Bridge
NEWARK BAY
ELIZABETH
BAYONNE
UPPER BAY
GOETHALS BRIDGE
KILL VAN KULL BRIDGE
BROOKLYN
Proposed Narrows Tunnel
STATEN ISLAND
PERTH AMBOY
LOWER BAY
OUTERBRIDGE CROSSING
Victory Bridge
THE PORT OF NEW YORK AUTHORITY
LOCATION OF PRINCIPAL CROSSINGS AND ARTERIAL HIGHWAYS IN PORT DISTRICT
SCALE IN MILES

Holland Tunnel, to allow for the tendency toward wider vehicles. The ventilation system is to be the same as that which has proved satisfactory in the Holland Tunnel. While the size of the tunnel will be somewhat larger than that of the Holland Tunnel, the studies indicate that its construction is entirely practicable and involves no new or untried operations. Characteristics of the materials through which the tunnel will be built are well known and, as revealed by preliminary borings, are practically identical with the conditions previously found at the Pennsylvania and the Holland Tunnels.

5. The tunnel and its approaches can be completed within a period of six years after it is authorized and funds become available, so that if funds should be raised in 1931, it is expected that the tunnel will be opened to traffic in 1937.

6. The estimated cost of the crossing is $96,000,000, which cost includes engineering and administration, the cost of real estate, interest during construction, the cost of financing and the cost of initial equipment for operation.

7. On the basis of conservative traffic anaylsis, it is estimated that during the first year after completion revenue will more than cover the annual interest charges, administration, maintenance and operation without imposing unreasonable toll charges on the traffic. It is estimated that the total traffic during the first year of operation will be 12,500,000 vehicles yielding $6,875,000 in gross revenue or, after deducting operating expenses estimated at $1,550,000 per annum, a net revenue of $5,325,000 or 5.55 per cent of the cost of construction. It is estimated that the annual traffic will reach the estimated capacity of the tunnel of 17,500,000 vehicles about the year 1946.

The work so far accomplished is briefly summarized as follows:

ORGANIZATION AND SCOPE OF PRELIMINARY INVESTIGATION

Upon authorization by the Legislatures immediate steps were taken to proceed with all phases of investigation bearing upon the project. The investigations have included traffic studies, topographical surveys and mapping, river and land borings and geological studies, designs for tunnel proper and accessory structures, approach and highway connection studies, real estate appraisal and financial studies.

The combined engineering staffs of the Port Authority and the former Holland Tunnel Commissions were promptly organized and augmented to carry on the field investigations and design work; in this work the Staff has had the assistance and advice of Mr. Ole Singstad, Chief Consulting Engineer on Tunnels and formerly Chief Engineer of the Holland Tunnel Commissions. In this investigation the Port Authority has had the advice and counsel of the following eminent Consulting Engineers: Professor Wm. H. Burr, Mr. James Forgie, Mr. Daniel E. Moran, Mr. Robert Ridgway and Col. George L. Watson.

The traffic studies were carried out by the Port Development Department of the Port Authority, partly in collaboration with the staff of the Board of Transportation. The real estate appraisals were made by the Real Estate Department of the Port Authority with the advice and assistance of Advisory Committees on both sides of the river.

To insure cooperation between the government of the City of New York and the Port Authority in the important and complex problem of developing a plan for the New York approach satisfactory to both, and in particular to coordinate the plans for the Hudson tunnel and the City's Crosstown tunnel leading to the 38th Street East River tunnel, a joint committee was appointed by the two agencies, consisting of Mr. Julius Miller, President of the Borough of Manhattan, Mr. John H. Delaney, Chairman of the Board of Transportation, Mr. Herman H. Smith, Chief Engineer of the Board of Estimate and Apportionment, representing the City, and the General Manager and the Chief Engineer of the Port Authority.

For the purpose of studying and developing plans that Committee appointed an Engineering Sub-Committee, consisting of Mr. Herman H. Smith, Chief Engineer of the Board of Estimate and Apportionment, Mr. Robert Ridgway, Chief Engineer of the Board of Transportation, Mr. C. M. Pinckney, Chief Engineer for the President of the Borough of Manhattan and the Chief Engineer of the Port Authority.

Similarly a Committee was formed to assure cooperation of the New Jersey State and local interests with the Port Authority in the development of a plan for the New Jersey approach. This Committee is composed of the following officials in New Jersey:— Mr. Arthur N. Pierson, President of the Senate, Mr. Joseph G. Wolber, State Senator, Mr. Russell S. Wise, Assemblyman, Mr. H. Otto Wittpenn, Member of New Jersey State Highway Commission, Mr. Jacob L. Bauer, State Highway Engineer and Mr. J. Ernest Thier, Supervisor of Roads, Bergen County. The Port Authority is represented by its Chairman, Vice-Chairman, General Manager and Chief Engineer.

The recommendations in this report are the result of not only the extensive studies of the Port Authority Staff, but of studies and conferences of these Committees.

TRAFFIC STUDIES

Extensive traffic studies were undertaken in order to secure a complete and up-to-date visualization of the flow of trans-Hudson vehicular traffic, its probable growth in future years, the probable volume and type of traffic that would flow to the Midtown Hudson tunnel, the revenue that may be derived therefrom to support the tunnel, the distribution of the tunnel traffic at the entrances and exits and the effect of this traffic on the city streets and highway connections.

The studies made over the experience of the Holland tunnel and the sixteen

ferries crossing the Hudson river between Yonkers and the Battery. In order to establish figures as to the origin, destination and route of travel, 202,000 motorists using the tunnel and ferries were interviewed by a corps of inspectors at selected periods during the winter of 1929–30 and the summer of 1930. About 7,500 motorists were also interviewed on the Paterson plankroad at a point in the vicinity of Homestead. The information secured was tabulated. Twenty-eight geographical zones of origin and destination of traffic were set up in New Jersey and twenty in New York. Time, distance and toll charges between various zones, the controlling factors upon which the number of vehicles using each route will depend were determined by test runs. The proportion of vehicles which would have found it advantageous to use the proposed tunnel as of 1929, as well as the distribution of traffic among the entrances and exists, was thus established.

Using these determinations it was then necessary to estimate the increase in traffic between the present time and the first full year of operation. In making such a forecast a conservative estimate of growth has been used, based on experience during the last nine years, taking into account however certain limiting factors, such as the slowing down as saturation points are reached both in car ownership and highway capacity. During the past nine years the growth in Hudson River traffic has been 211 per cent; East River traffic, 283 per cent; gasoline consumption, 263 per cent. However, in view of the limiting factors previously noted the rate of increase for the next nine years has been assumed to be 100 per cent only.

The distribution of trans-Hudson traffic as of 1938 is given on the attached chart of traffic studies which shows the recorded annual vehicular traffic for all Hudson river crossings up to the present time and the estimated annual traffic up to the year 1948.

The total trans-Hudson traffic in 1938 is estimated to be 47,000,000 vehicles of which the Midtown Hudson tunnel will carry 12,500,000, the Holland tunnel 13,500,000, the Hudson River bridge 11,500,000 and the ferries 9,500,000. The opening of the new tunnel to traffic will affect the Holland tunnel, which at that time will be operating at close to capacity, to the extent of reducing its traffic for the year 1938 as compared to the year 1937 by approximately 2,900,000 vehicles, but will leave to the Holland Tunnel in the year 1938 a traffic well in excess of the present volume. The Hudson River bridge traffic in 1938 will be reduced only slightly below the 1937 level.

The chart has been prepared on the assumption that the total trans-Hudson traffic in 1948 will be 75,000,000 vehicles. The tunnel is assumed to approach its capacity traffic volume in 1946. While projection of these figures into the future must necessarily be only approximate it is believed that this is a fair representation of the situation. The traffic distribution will, of course, be changed in the event of opening a fourth crossing at any time during the period shown.

Traffic studies were also made to determine the effect of the tunnel traffic on the city streets. The Port of New York Authority Staff cooperated with the Board of Transportation of New York City in placing a cordon of inspectors around an area in Manhattan bounded by Eighth avenue on the east, 41st street on the north, Twelfth avenue on the west and 35th street on the south. Traffic was clocked for a period of twelve hours. All of these street clockings have been tabulated to show hourly traffic segregated by types of vehicles.

The distribution of tunnel traffic in 1938, as determined by the traffic studies, is as follows:

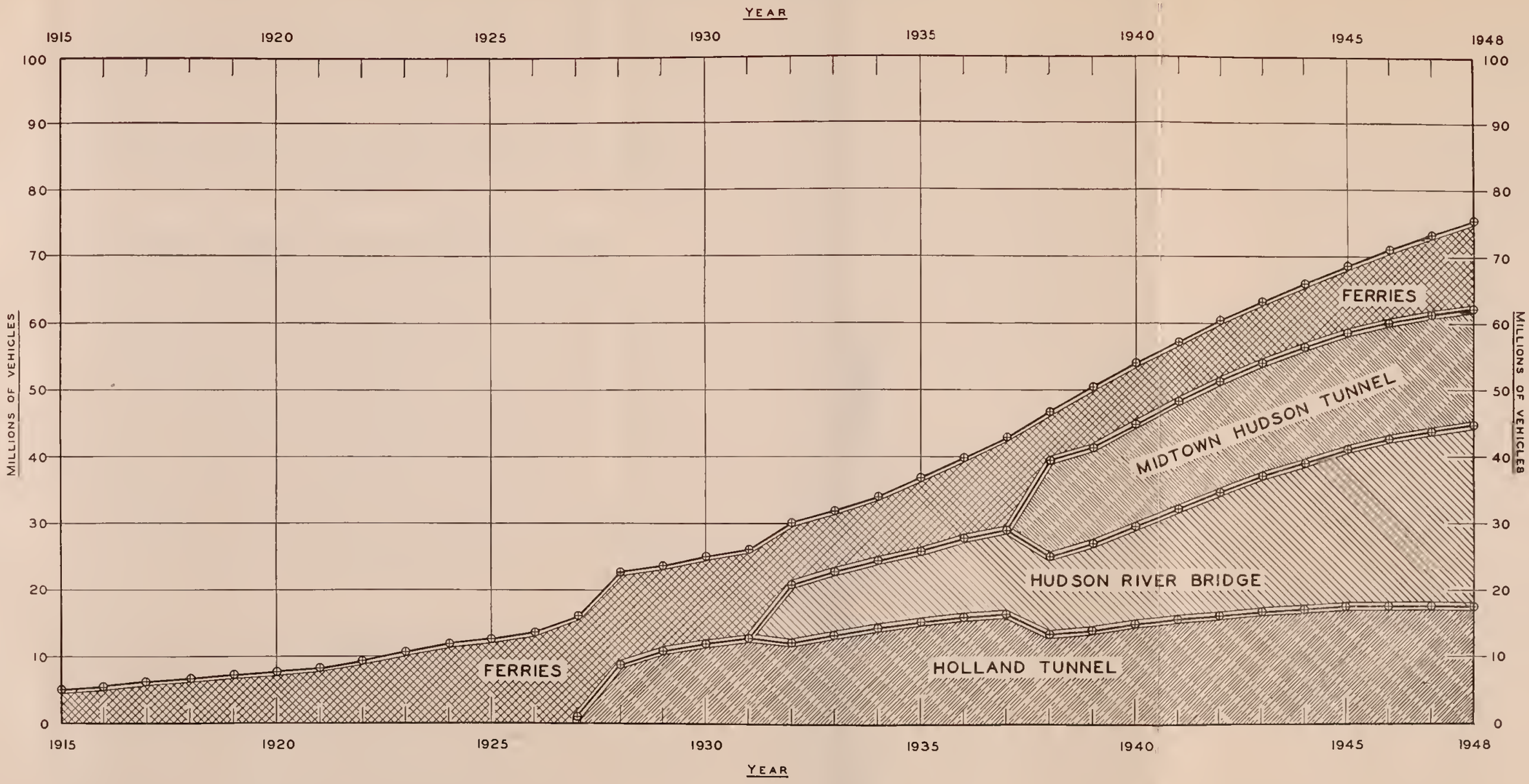
A total of 12,500,000 vehicles is estimated to use the river tunnel. At the Manhattan portal 4,900,000 of these vehicles will flow to and from the north, 3,100,000 to and from the south and 4,500,000 to and from the east. Of the 4,900,000 vehicles flowing to and from the north, approximately 32 per cent or 1,600,000 will use the West Side Express Highway and 68 per cent or 3,300,000 will use the city streets. Of the 3,100,000 vehicles flowing to and from the south, 67 per cent or 2,100,000 will use the West Side Express Highway and 33 per cent or 1,000,000 will use the city streets. Of the 4,500,000 vehicles flowing to and from the east, approximately 82 per cent or 3,700,000 vehicles will use the Crosstown tunnel, if provided, to points approximately east of Fifth avenue and to Long Island, and 18 per cent or 800,000 vehicles will use the crosstown city streets.

In New Jersey the traffic studies indicate that 6,600,000 vehicles or 53 per cent of the tunnel traffic would enter or leave the approach at Homestead west of the Palisades and 5,900,000 vehicles or 47 per cent would enter or leave the Weehawken plaza from or to points on top or east of the Palisades. Of the 6,600,000 vehicles estimated to enter or leave at Homestead, 4,400,000 vehicles will flow to and from the north and northwest and 2,200,000 vehicles to and from the south and southwest. At the Weehawken plaza, 2,600,000 of the total of 5,900,000 vehicles will flow to and from the north and 3,300,000 to and from the south. With an intermediate connection provided at the Hudson county boulevard, about 40 per cent of the 5,900,000 vehicles with origin or destination on top of the Palisades will go or come from the Weehawken plaza via the approach highway.

SURVEYS AND MAPPING

For the preparation of working maps upon which to base studies and plans, all available information contained on existing maps was gathered together from various sources and compiled. In the case of the Manhattan area this information was found to be fairly complete and accurate and a relatively small amount of field work was necessary to correlate and check the information. The entire area including 29th street on the south and 47th street on the north, the Hudson river on the west as far as the New Jersey pierhead line and Sixth avenue on the east was plotted on a single large plan using a scale of 100 ft. = 1 inch.

RECORDED AND ESTIMATED ANNUAL VEHICULAR TRAFFIC FOR ALL HUDSON RIVER CROSSINGS
YEARS 1915 TO 1948 INCLUSIVE



THE PORT OF NEW YORK AUTHORITY
MIDTOWN HUDSON TUNNEL

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In New Jersey the information available was found to be inadequate and not correlated to meet the needs of the situation and complete detailed topographical surveys were required covering the entire area from the Hudson River on the east to County avenue in Secaucus on the west and from Tenth street in Union City on the south to 47th street in Union City on the north. This information was plotted on three large maps using the scale of 100 ft. = 1 inch.

In both Manhattan and New Jersey extended accurate level runs were made to tie in the topographical information and to furnish the necessary points for construction purposes.

The triangulation work essential to the accurate mapping of the topography on the two sides of the river has also been carried on. Base lines were established east and west of the Palisades. A supplementary base line was also established in Manhattan.

LAND AND RIVER BORINGS AND GEOLOGICAL STUDIES

Much is known of the sub-surface conditions in the general vicinity of the proposed tunnel from the borings and other information available from the construction of the Pennsylvania railroad tunnels and various construction work in Manhattan. It was essential to verify this information by definite determinations at the site. Borings have, therefore, been made at the proposed location under a contract with the Kennedy-Riegger Drilling Company. River borings were made between pierhead lines on lines opposite 34th street and 38th street, Manhattan. Land borings were made at 37th, 38th and 39th streets in Manhattan and between the pierhead line and the east face of the Palisades in New Jersey.

The geological information obtained indicates that on the Manhattan shore landward of the bulkhead line the greater portion of the approach tunnel work will be in rock. At the pierhead line this rock floor is at such depth as to lie entirely below the tunnel. The rock then continues for the width of the river at a considerable depth so that westward from the bulkhead line the tubes will be driven entirely in silt.

At the New Jersey pierhead line the rock is 264 feet below mean high water and continues low as far as the bulkhead line, from that point rising rapidly. The information obtained from borings corresponds to that available from the Pennsylvania railroad tunnels which were constructed in almost identical ground at 32d street.

In analyzing the borings and interpreting the sub-surface condition, the Port Authority has had the services of Professor Charles P. Berkey. His conclusions indicate that geologic formation for a considerable distance up and down the river is sufficiently uniform to have little bearing on the choice of site. The general geologic formations encountered are those found in this vicinity, namely, fill, river silts and muds, bouldery glacial drift, Palisades trap, Newark sandstones and shales, and Manhattan mica schist.

DESIGN WORK

Extensive studies have been made with respect to type of tunnel construction and the proportions of a shield driven tunnel to meet the traffic demands for clearances, width of roadway and so forth.

For the construction of the under-river portion of the tunnel two alternate methods were investigated, *i. e.* the precast or open trench method and the shield driven method. By the trench method the tunnels are built in sections on land or in dry dock, are then floated, towed to the site and sunk into position in a trench which has been previously excavated to receive them. This trench type of construction offers some advantages over the shield method but it also possesses several manifest disadvantages, the principal of which are the hazards to and from river traffic by reason of the floating equipment and the unknown characteristics of the silt under conditions such as would obtain in dredging a deep trench transverse to the river current. On the other hand the construction of the Pennsylvania railroad tunnels and of the Holland tunnel has already demonstrated conclusively the practicability of the shield driven method under similar conditions. An extensive investigation of the relative costs involved and construction conditions, in which several types of precast trench tunnel were studied, led to the abandonment of a precast trench tunnel method in favor of a shield driven construction.

The tunnel ring will be 31 feet in outside diameter and will consist of cast iron segments which have been used successfully in the Holland tunnel. Studies have been made to determine the advisability of using other materials in place of cast iron for the tunnel ring, but after investigation the use of any other material seems undesirable under the conditions peculiar to the Hudson river material.

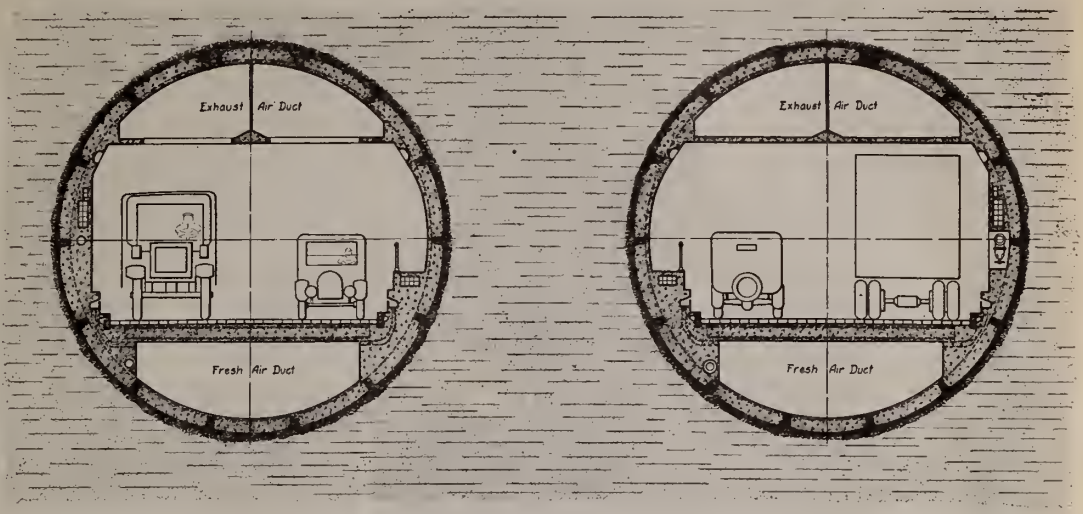
Appurtenant structures, such as ventilation buildings, and equipment, have also been studied.

To determine the physical proportions of the tubes all available information has been collected as to vertical clearances used or required for structures over highways in various states, present vehicle heights and future trends in motor vehicle widths and side overhang. Based on these studies ample vertical and side clearances have been adopted for design purposes. The investigations indicate a trend toward wider vehicles to allow for which a minimum roadway width of 21 feet between curbs has been tentatively adopted.

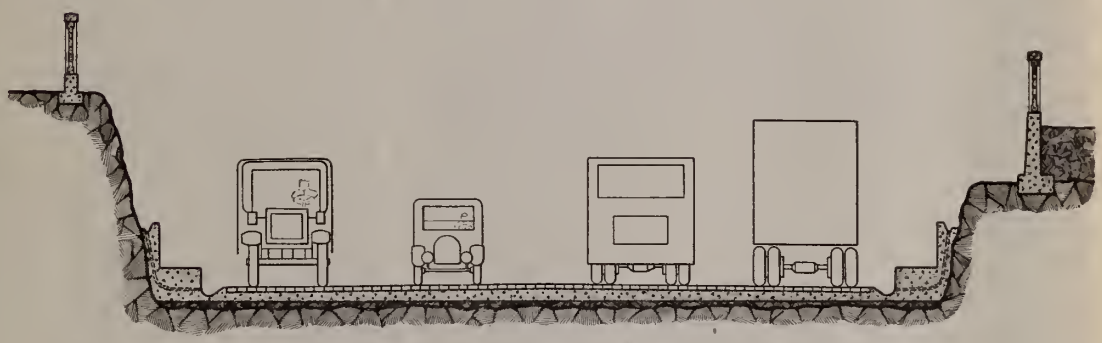
Extensive design studies have also been made for the approach structures. In New York the approach will be built largely by the usual methods of subway construction. The open cut highway of the New Jersey approach lends itself to simplicity of design and comparative ease of construction.

NEW YORK APPROACH AND TERMINUS

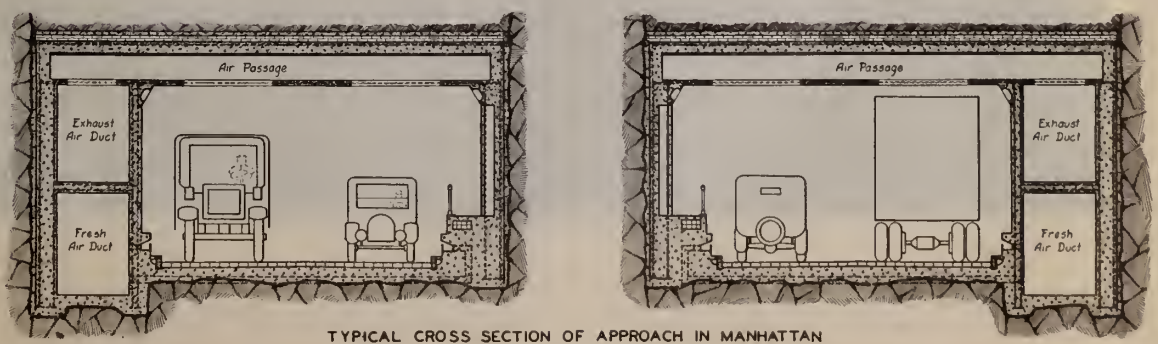
Studies for the New York approach and terminus have been made with a view to facilitate the movement of the traffic estimated to flow to and from the tunnel



TYPICAL CROSS SECTION OF UNDER RIVER TUNNEL



TYPICAL CROSS SECTION OF OPEN CUT APPROACH IN NEW JERSEY



TYPICAL CROSS SECTION OF APPROACH IN MANHATTAN

Birdseye view showing projected location of Midtown Hudson Tunnel and its New Jersey approach

Birdseye view showing projected location of Midtown Hudson Tunnel and its New York approach

and at the same time avoid congestion on the city streets. Consideration was given to the desirability of connecting the Midtown Hudson tunnel directly with the City's Crosstown Tunnel in case the latter should be built, since, in accordance with traffic estimates, about 30 per cent of the trans-Hudson traffic will desire to use such a connection and because it is desirable that this traffic be kept away from the streets.

It was also considered essential that, if possible, no city streets be closed, that the elimination of ratable property be reduced to a minimum, and that interference with the West Side improvement of the New York Central Railroad and other railroad facilities be minimized.

In addition to the above essential considerations the studies were based upon certain requirements with respect to minimum clearances, limiting grades, minimum curvature and traffic control.

Numerous schemes have been developed and studied but, while these studies plainly indicate the feasibility of a practicable solution and outstanding merits of the general location of the exit and entrance plazas herein proposed, no definite plan is recommended at this time. The problem of developing the most satisfactory plan and its many essential details is of such importance and has such ramifications that it is considered desirable to continue the studies for the New York approach in collaboration with the City.

However the conclusion may be drawn, from the studies so far made, that the location of the New York terminal facilities for the Midtown Hudson tunnel in the vicinity of 38th street, west of Ninth avenue, offers a workable solution and lends itself to simple and direct connection with the City's Crosstown Tunnel in case the latter should be decided upon.

Consideration has been given to the feasibility of a direct connection between the tunnel and the City's Elevated Express Highway along Twelfth avenue, but, in view of the ramifications involved, it has been concluded that it is not advisable at the present time to provide for such a connection.

THE NEW JERSEY APPROACH AND HIGHWAY CONNECTIONS

A solution of the New Jersey approach problem must reckon with the natural barrier offered by the Palisades to access to the river tunnel. This feature was recognized by the Legislatures in making the provisions in the statutes for a direct connection to the west side of the Palisades as well as for entrance and exit on the east side of the Palisades in Weehawken. The open cut highway approach is one of several solutions which have been considered. Two of these schemes have been outstanding and both offered workable solutions, namely the open cut approach highway which would take advantage of a natural valley near the east face of the cliffs and carry traffic over the Palisades and a tunnel consisting of separate bores for each roadway which would carry traffic through the Palisades at a location

approximately half of a mile south of the line of the river crossing. The two schemes have been studied in detail; both schemes provide for entrances and exits at Weehawken; both involve approximately equal construction costs; both schemes present meritorious and workable solutions from an engineering point of view.

As is natural in the case of alternative schemes each presents its peculiar inherent advantages. The tunnel scheme offers the unquestionable advantage to the through traffic of easier grades and a somewhat more direct route to traffic coming from the south and southwest. The open highway on the other hand involves smaller cost of operation and with its contemplated wider roadway and connection with the Hudson county boulevard, affords greater traffic flexibility and serves more adequately the interests of the communities on top of the Palisades and to the north.

The easterly ramp of the approach highway would have a grade not in excess of $3\frac{1}{2}$ per cent which is the same as the existing grades on the approaches to the East river bridges, in the Holland tunnel and as now proposed for the under river section of the Midtown Hudson tunnel. The westerly ramp of the approach would have a general grade of approximately 2 per cent.

Street intersections will be avoided by carrying the surface streets over the depressed approach highway.

The plan can be so arranged that all tolls may be collected at the Weehawken or easterly extremity of the open cut, at the entrance and exit of the river tunnel, thus permitting unrestricted use of the approach as a highway providing free access for local traffic between Weekawken and communities east and south of the Palisades. By means of the connections with the Hudson county boulevard traffic may flow in both directions on the approach highway eastward either to the river tunnel or to the local communities or westward to Routes Nos. 1 and 3 and the proposed route across the Meadows to connect with Route No. 10.

The construction of the open cut approach would involve the excavation of approximately twice as much material as would the tunnel approach scheme. At practically no extra cost to the Port Authority, provision can be made for dumping the large excess quantity of spoil secured from the open cut on the Meadows to provide fill for the much needed highway leading to State Route No. 10, thus materially assisting the New Jersey State Highway Commission in providing a very essential approach. In consideration of this aid and in view of the availability of the open cut approach for other than tunnel traffic, it is proposed that the entire New Jersey approach west of the tunnel plaza at Weehawken be taken over and maintained by the State Highway Commission.

Thus the choice between the two schemes becomes largely one which concerns the New Jersey interests, as well as those of the Port Authority and the users of the tunnel. In studying the New Jersey approach close contact has been maintained with the New Jersey State Highway Commission since the approach con-

nections will in fact form an extension of the highway system in carrying traffic from the main arteries to the river tunnel. The alternative studies were also reviewed by the New Jersey Approach Joint Committee which voices the interests of the New Jersey communities and adjacent territories served by the facility. Both the State Highway interests and the New Jersey Committee have favored the open cut approach highway.

Further studies will be made in an effort to develop a final plan which will embody as far as practicable the advantages of easier grades inherent in the tunnel scheme and ease of connections, especially on top of the Palisades, possessed by the open highway scheme.

ESTIMATED COST

The preliminary work of investigation and design, including the appraisal of real estate and plans for financing, have now been carried to a point which makes possible the presentation of a conservative estimate of cost of the Midtown Hudson tunnel as follows:

Construction and initial equipment required for operation	$57,800,000
Engineering, administration and contingencies	8,700,000
Real estate	17,000,000
Interest during construction and cost of financing	12,500,000
Total estimated cost	$96,000,000

ESTIMATED REVENUE

The statement following gives for the years 1938, 1940, 1942, 1944, 1946 and thereafter the estimated gross revenue and net operating income, based upon an average toll rate of fifty-five cents per vehicle and an initial cost of $96,000,000.

Year	*Estimated Vehicular Traffic*	*Gross Revenue from Tolls*	*Administration Operation Maintenance*	*Net Operating Income Available for Interest and Amortization*	*Per Cent of Net Operating Income to Estimated Cost*
1938	12,500,000	$6,875,000	$1,550,000	$5,325,000	5.55%
1940	14,700,000	8,085,000	1,550,000	6,535,000	6.81
1942	16,200,000	8,910,000	1,550,000	7,360,000	7.67
1944	17,200,000	9,460,000	1,550,000	7,910,000	8.24
1946 and thereafter	17,500,000	9,625,000	1,550,000	8,075,000	8.41

(See also attached financial statement.)

ACKNOWLEDGMENTS

The Port Authority Staff has been aided in its studies by valuable advice, helpful assistance and information for which it is indebted to many individuals, corporations and associations.

In its traffic studies it has received the assistance of the Board of Transportation of the City of New York, the New Jersey State Highway Department, the Commissioners of Motor Vehicles of both States, the U. S. Bureau of Public Roads, the National Automobile Chamber of Commerce and various motor vehicle associations, manufacturers and operators.

The staff was materially assisted in its studies of sub-surface conditions and the work of taking borings by the Pennsylvania railroad, the Erie railroad and the New York Central railroad, the Department of Docks of New York City, Furness Withy & Company and other agencies and individuals who furnished information or cooperated in permitting borings to be made on their properties. Permits for making the borings in the bed of the river were furnished by the Captain of the Port.

For permission to occupy private property in preparing base lines and stations for triangulation, acknowledgment is made to the Officers of the Railroads previously mentioned, the Department of Parks and Public Properties of Union City and to numerous individuals.

For the valuable information secured from available maps the Staff is indebted to municipal agencies in both States, the Railroads, government agencies, the Interboro Rapid Transit Company and to other associations and individuals.

Respectfully submitted,

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Geo. L. Watson (signed)
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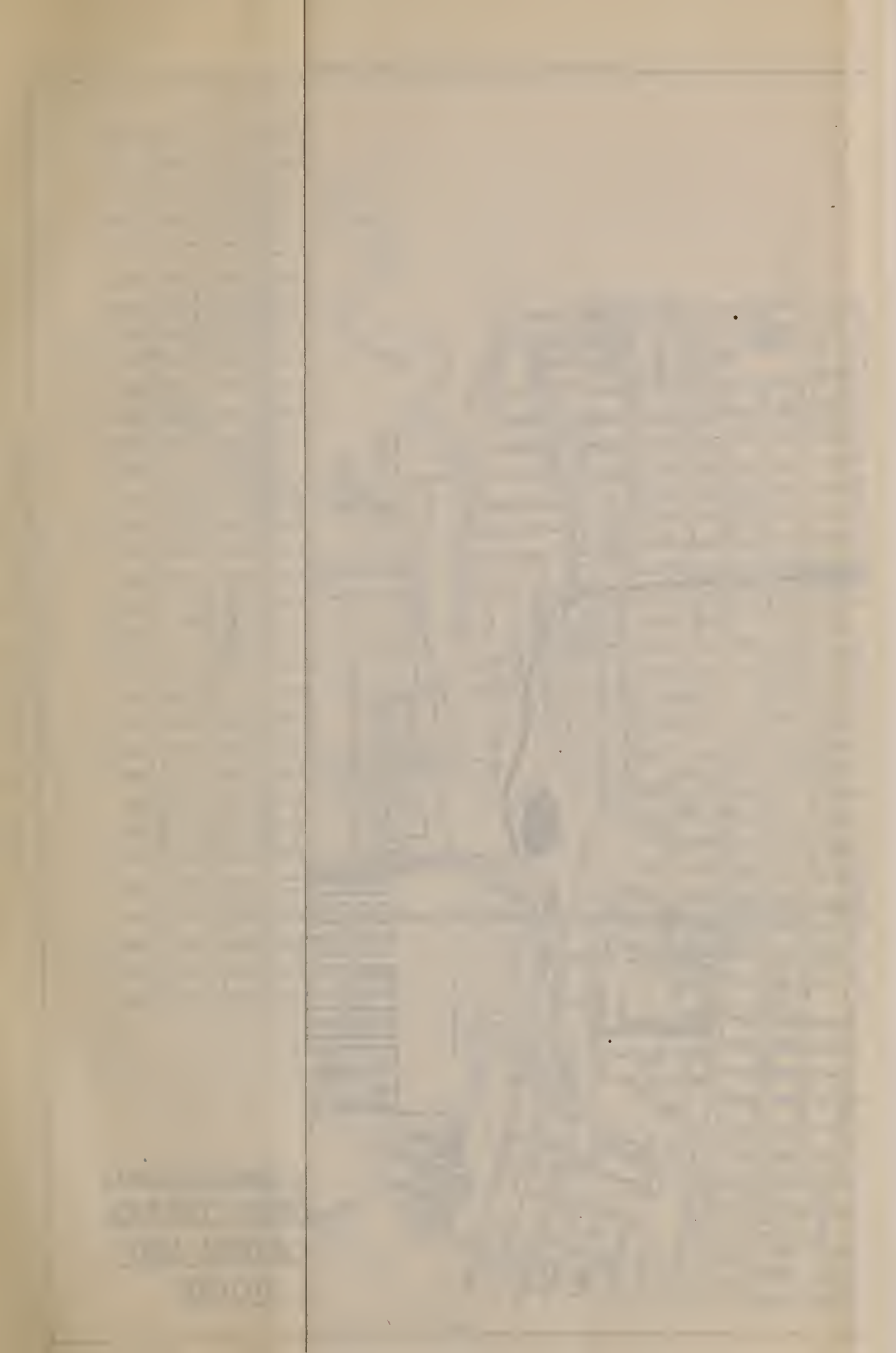

THE PORT OF NEW YORK AUTHORITY

MIDTOWN-HUDSON TUNNEL
GENERAL LOCATION MAP
TENTATIVE ROUTE

FINANCIAL FORECAST OF ISSUE OF 4¼ PER CENT SERIAL BONDS TO COVER COST OF MIDTOWN HUDSON TUNNEL

(Basis of 55c average toll rate)

Year	Estimated vehicular traffic	Gross revenue at 55 cents	Operating expenses	Estimated net revenue	Bonds outstanding	Interest at 4¼ per cent	Fixed charges		Surplus	Accumulated surplus
							Retirement	Total		
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)
1938	12,500,000	$6,875,000	$1,550,000	$5,325,000	$96,000,000	$4,080,000	.....	$4,080,000	$1,245,000	$1,245,000
1939	13,700,000	7,535,000	1,550,000	5,985,000	96,000,000	4,080,000	.....	4,080,000	1,905,000	3,150,000
1940	14,700,000	8,085,000	1,550,000	6,535,000	96,000,000	4,080,000	.....	4,080,000	2,455,000	5,605,000
1941	15,500,000	8,525,000	1,550,000	6,975,000	96,000,000	4,080,000	$1,000,000	5,080,000	1,895,000	7,500,000
1942	16,200,000	8,910,000	1,550,000	7,360,000	95,000,000	4,037,500	1,000,000	5,037,500	2,322,500	9,822,500
1943	16,700,000	9,185,000	1,550,000	7,635,000	94,000,000	3,995,000	2,000,000	5,995,000	1,640,000	11,462,500
1944	17,200,000	9,460,000	1,550,000	7,910,000	92,000,000	3,910,000	2,000,000	5,910,000	2,000,000	13,462,500
1945	17,500,000	9,625,000	1,550,000	8,075,000	90,000,000	3,825,000	3,000,000	6,825,000	1,250,000	14,712,500
1946	17,500,000	9,625,000	1,550,000	8,075,000	87,000,000	3,697,500	3,000,000	6,697,500	1,377,500	16,090,000
1947	17,500,000	9,625,000	1,550,000	8,075,000	84,000,000	3,570,000	3,000,000	6,570,000	1,505,000	17,595,000
1948	17,500,000	9,625,000	1,550,000	8,075,000	81,000,000	3,442,500	3,000,000	6,442,000	1,633,000	19,228,000
1949	17,500,000	9,625,000	1,550,000	8,075,000	78,000,000	3,315,000	3,000,000	6,315,000	1,760,000	20,988,000
1950	17,500,000	9,625,000	1,550,000	8,075,000	75,000,000	3,187,500	3,000,000	6,187,500	1,887,500	22,875,500
1951	17,500,000	9,625,000	1,550,000	8,075,000	72,000,000	3,060,000	3,000,000	6,060,000	2,015,000	24,890,500
1952	17,500,000	9,625,000	1,550,000	8,075,000	69,000,000	2,932,500	3,000,000	5,932,500	2,142,500	27,033,000
1953	17,500,000	9,625,000	1,550,000	8,075,000	66,000,000	2,805,000	3,500,000	6,305,000	1,770,000	28,803,000
1954	17,500,000	9,625,000	1,550,000	8,075,000	62,500,000	2,656,250	4,000,000	6,656,250	1,418,750	30,221,750
1955	17,500,000	9,625,000	1,550,000	8,075,000	58,500,000	2,486,250	4,000,000	6,486,250	1,588,750	31,810,500
1956	17,500,000	9,625,000	1,550,000	8,075,000	54,500,000	2,316,250	4,500,000	6,816,250	1,258,750	33,069,250
1957	17,500,000	9,625,000	1,550,000	8,075,000	50,000,000	2,125,000	4,500,000	6,625,000	1,450,000	34,519,250
1958	17,500,000	9,625,000	1,550,000	8,075,000	45,500,000	1,933,750	4,500,000	6,433,750	1,641,250	36,160,500
1959	17,500,000	9,625,000	1,550,000	8,075,000	41,000,000	1,742,500	4,500,000	6,242,500	1,832,500	37,993,000
1960	17,500,000	9,625,000	1,550,000	8,075,000	36,500,000	1,551,250	4,500,000	6,051,250	2,023,750	40,016,750
1961	17,500,000	9,625,000	1,550,000	8,075,000	32,000,000	1,360,000	4,500,000	5,860,000	2,215,000	42,231,750
1962	17,500,000	9,625,000	1,550,000	8,075,000	27,500,000	1,168,750	4,500,000	5,668,750	2,406,250	44,638,000
1963	17,500,000	9,625,000	1,550,000	8,075,000	23,000,000	977,500	4,500,000	5,477,500	2,597,500	47,235,500
1964	17,500,000	9,625,000	1,550,000	8,075,000	18,500,000	786,250	4,500,000	5,286,250	2,788,750	50,024,250
1965	17,500,000	9,625,000	1,550,000	8,075,000	14,000,000	595,000	4,500,000	5,095,000	2,980,000	53,004,250
1966	17,500,000	9,625,000	1,550,000	8,075,000	9,500,000	403,750	3,000,000	3,403,750	4,671,250	57,675,500
1967	17,500,000	9,625,000	1,550,000	8,075,000	6,500,000	276,250	3,000,000	3,276,250	4,798,750	62,472,250
1968	17,500,000	9,625,000	1,550,000	8,075,000	3,500,000	148,750	1,500,000	1,648,750	6,426,250	68,900,500
1969	17,500,000	9,625,000	1,550,000	8,075,000	2,000,000	85,000	1,000,000	1,085,000	6,990,000	75,890,500
1970	17,500,000	9,625,000	1,550,000	8,075,000	1,000,000	42,500	1,000,000	1,042,500	7,032,500	82,923,000
Total	561,500,000	$308,825,000	$51,150,000	$257,675,000	.....	$78,752,500	$96,000,000	$174,752,000	.....	.....